(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
12 June 2008 (12.06.2008)

PCT

(10) International Publication Number
WO 2008/070769 A1

(51) International Patent Classification:
A61M 25/00 (2006.01) *A61M 25/04* (2006.01)
A61M 27/00 (2006.01) *A61M 25/01* (2006.01)
A61M 31/00 (2006.01)

(21) International Application Number:
PCT/US2007/086629

(22) International Filing Date:
6 December 2007 (06.12.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/868,901 6 December 2006 (06.12.2006) US
60/868,904 6 December 2006 (06.12.2006) US

(71) Applicant *(for all designated States except US)*: **MEDTRONIC, INC.** [US/US]; 710 Medtronic Parkway NE, Minneapolis, MN 55432-5604 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **KEIMEL, Jack** [US/US]; 6 Charley Lake Court, North Oaks, Minnesota 55127 (US). **KAEMMERER, William, F.** [US/US]; 4900 Trillium Lane, Edina, Minnesota 55435 (US). **MORRIS, Mary, M.** [US/US]; 2917 Woodale Drive, Mounds View, Minnesota 55112 (US).

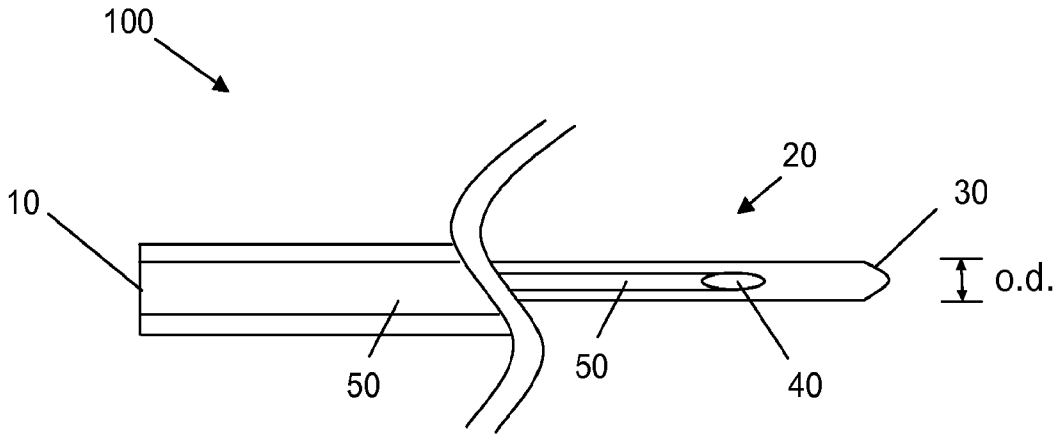
(74) Agent: **CAMPBELL, Keith**; Campbell Nelson Whipps, LLC, 408 St. Peter Street, Suite 240, St. Paul, MN 55102 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

(54) **Title:** INTRATHECAL CATHETER



(57) **Abstract:** An intrathecal catheter for delivering fluid to, or withdrawing fluid from, the cerebrospinal fluid compartment of a patient, includes a proximal end and a distal portion. The distal portion has an outer diameter of about 1 mm or less, a bending stiffness of about 0.002 pounds per square inch or less, and a distal end. A delivery region is located between the proximal end and the distal end, and a lumen extends from the proximal end to the delivery region. The catheter may further include a coiled structure region to prevent dislodgement of the catheter from a tissue in which the coiled structure is implanted, for example the cisterna magna. The catheter may also include tines to anchor portions of the catheter, for example to a portion of the spinal canal.

WO 2008/070769 A1

INTRATHECAL CATHETER

RELATED APPLICATIONS

[001] This Application claims the benefit of Provisional Application Serial No. 60/868,901, filed December 6, 2006, and of Provisional Application Serial No. 60/868,904, filed December 6, 2006, which applications are hereby incorporated herein by reference in their respective entireties to the extent that they do not conflict with the present disclosure.

FIELD

[002] The present disclosure relates, *inter alia*, to implantable medical catheters, and particularly to intrathecal catheters.

BACKGROUND

[003] A variety of catheters are available for delivering therapeutic agents to patients. Configurations of the catheters vary according to the use for which they are intended. For example, intravascular catheters may include a coiled region that presses against the vasculature to hold the catheter in place during use. The use of tines has also been employed for purposes of anchoring a catheter relative to a tissue location. The materials and properties of the catheters may be selected to be compatible with the therapeutic agent being delivered and the tissue into which the catheter is to be implanted.

[004] Recently, therapies have been proposed for delivering therapeutic agents to the cisterna magna. However, to date, no catheters have been described that would be suitable for such delivery, particular for long term delivery; *e.g.*, as typically associated with implantable infusion devices.

SUMMARY

[005] The present disclosure describes catheters and kits and systems suitable for delivering therapeutic agents to the cisterna magna, particularly when the catheters are advanced rostrally through the spinal canal to the cisterna magna.

[006] In an embodiment, a catheter includes a proximal end and a distal portion. The distal portion has an outer diameter of about 1 mm or less, a bending stiffness of between about about 0.00005 pound inch squared (1.4×10^{-8} kg-meter squared) to about 0.002 pound inch squared (5.8×10^{-7} kg-meter squared), and a distal end. A delivery region is located between the proximal end and the distal end, and a lumen extends from the proximal end to the delivery region. The material forming the distal portion of the catheter imparts a sufficient hoop strength such that the lumen resists collapsing when implanted in the cerebrospinal fluid compartment of a subject. The catheter may further include a coiled structure region to prevent dislodgement of the catheter from a tissue in which the coiled structure is implanted, for example the cisterna magna, or to allow for growth of the patient in height when implanted in a young patient. The catheter may also include tines to anchor portions of the catheter, for example to a portion of the spinal canal.

[007] In an embodiment, a catheter includes a proximal end and a distal portion. The distal portion includes a delivery region and a coiled structure region. A lumen extends from the proximal end to the delivery region. One or more tines are located on the catheter proximal to the delivery region and the coiled structure region.

[008] The catheters described herein provide one or more advantages over existing catheters. For example, in various embodiments, the catheters include a flexible distal end portion that can reduce or prevent tissue damage when being advanced through delicate tissue such as the cisterna magna. In various embodiments, the catheters are configured to provide anchoring within the cisterna magna or spinal canal to prevent dislodgement of a delivery region of the catheter from the cisterna magna. These and other advantages will become evident upon reading the disclosure that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[009] **FIG. 1** is a schematic longitudinal cross sectional view of a representative catheter.

[0010] **FIG. 2A** is schematic side view of a representative catheter.

[0011] **FIG. 2B** is a schematic exploded side view of a representative catheter, adaptor, and second catheter.

[0012] **FIG. 3** is a schematic longitudinal cross section of a distal portion of a representative catheter.

[0013] **FIG. 4** is a schematic longitudinal cross section of a representative distal portion of a catheter with a stylet inserted into a lumen of the catheter.

[0014] **FIG. 5** is a schematic longitudinal cross section of a stylet inserted into a lumen of a catheter.

[0015] **FIG. 6** is a schematic longitudinal cross section of a portion of a catheter including a visualization marker.

[0016] **FIG. 7** is a schematic longitudinal cross section of a representative distal portion of a catheter with a stylet inserted into a lumen of the catheter.

[0017] **FIG. 8** is a schematic perspective view of a coiled structure region of a representative catheter.

[0018] **FIG. 9** is a schematic longitudinal section of a portion of a representative catheter having a coiled structure region and tines.

[0019] **FIG. 10** is a schematic side view of an implantable infusion device with an attached catheter.

[0020] **FIG. 11** is a schematic view of an infusion device and associated catheter implanted in a patient.

[0021] The drawings are not necessarily to scale. Like numbers used in the figures refer to like components, steps and the like. However, it will be understood that the use of a number to refer to a component in a given figure is not intended to limit the component in another figure labeled with the same number.

DETAILED DESCRIPTION

[0022] In the following detailed description, reference is made to the accompanying drawings that form a part hereof, and in which are shown by way of illustration several specific embodiments of devices, kits, systems and methods. It is to be understood that other embodiments are contemplated and may be made without departing from the scope or spirit of the present invention. The following detailed description, therefore, is not to be taken in a limiting sense.

[0023] Devices and methods for delivering large molecules to the central nervous system (CNS) are discussed. The devices and methods described allow for less invasive and more effective procedures to be employed for delivering medications comprised of drugs, small molecules, or large molecules to the brain.

[0024] Definitions

[0025] All scientific and technical terms used herein have meanings commonly used in the art unless otherwise specified. The definitions provided herein are to facilitate understanding of certain terms used frequently herein and are not meant to limit the scope of the present disclosure.

[0026] As used herein, "the cerebrospinal fluid compartment" of a subject means the space within the central nervous system within the anatomy of the subject that is filled with cerebrospinal fluid. The cerebrospinal fluid compartment comprises the cisterna magna, the lateral ventricles, the third ventricle, the fourth ventricle, the foramen of Magendie, the foramen of Monro, the formina of Luschka, the cerebral aquaduct, the subarachnoid space surrounding the brain and the spinal cord, the dural venous sinuses, spaces surrounding the cranial nerves, and other spaces of the central nervous system containing cerebrospinal fluid..

[0027] As used herein, "visualization marker" means material that is visible by surgical navigation instrumentation. A marker may be a discrete band or may be in any other suitable form for visualization purposes. Markers may comprise radiopaque material, such as platinum, tungsten, gold or iridium. Markers may be incorporated into catheter material or may be affixed to a portion of a catheter.

[0028] As used herein, "subject" means an animal into which a catheter or a portion thereof may be implanted and includes mammals, such as humans.

[0029] As used herein, "comprising", "including", and the like are used in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to . . ."

[0030] As used in this specification and the appended claims, the singular forms "a", "an", and "the" encompass embodiments having plural referents, unless the content clearly dictates otherwise. As used in this specification and the appended claims, the term "or" is generally employed in its sense including "and/or" unless the content clearly dictates otherwise.

[0031] Abbreviations of units of measurements as used herein are abbreviations commonly used in the art unless otherwise specified. For example, "mm" means millimeter, "cm" means centimeter, and "kg" means kilogram.

[0032] Described herein are catheters having properties that are useful for delivering fluid to or withdrawing fluid from the cisterna magna of a subject. However, it will be understood that the properties of the catheters may be useful for delivering or withdrawing fluid to other areas of a subject.

[0033] Referring to **FIG. 1**, catheter **100** has a proximal end **10** and a distal portion **20**. As used herein, "proximal" refers to the portion of the catheter closer to a fluid delivery or withdrawal device and "distal" refers to the portion of the catheter further from the fluid delivery or withdrawal device when in use. Distal portion **20** comprises a distal end **30** and a delivery region **40**. Catheter **100** comprises a lumen **50** extending from proximal end **10** to delivery region **40**. Delivery region **40** in **FIG. 1** is depicted as a side hole. However, it will be understood that delivery region **40** may be one or more side holes, one or more porous regions (not shown) that extend around or substantially around a portion of distal portion **20** of catheter **100**, an opening (not shown) at distal end **30**, or the like. It may be desirable in many circumstances to have more than one opening for fluid to be delivered or withdrawn in case one or more openings becomes clogged during or following implantation of catheter **100**.

[0034] As shown in **FIG. 1**, distal portion **20** of catheter **100** has an outer diameter (**o.d.**). In various embodiments **o.d.** of distal portion **20** is less than about 1 mm. For example,

o.d. may be less than 0.75 mm or less than 0.62 mm. Catheter **100** having a distal portion **20 with** an **o.d.** of less than about 1 mm may tend to be too limp to be pushed large distances within a subject's body, such as from the intrathecal lumbar region to the cisterna magna, particularly if made from certain polymeric materials. However, such a limp catheter **100** tends to reduce the chance of damaging tissue into which catheter **100** is inserted, such as the intrathecal space. Accordingly, it may be desirable to employ a stylet **200** (see, *e.g.*, **FIG. 3**) to direct catheter **100** to the appropriate location within the subject. Of course, a long introducer (not shown) or guiding catheter (not shown) may be used to provide a guide through which the thinner catheter **100** could be pushed without bending or going off course.

[0035] In various embodiments, distal portion **20** of catheter **100** has a bending stiffness low enough to avoid significant damage to tissue, such as the arachnoid membrane, as distal portion **20** of catheter **100** is advanced through the tissue. Bending stiffness can be measured using the following formula:

$M \rho = E I,$
where M = bending moment;
ρ = radius of curvature;
E = Young's Modulus for the material selected; and
I = moment of inertia for the beam.

[0036] The moment of inertia for simple cross sections are readily available to those skilled in the art, e.g., through textbooks or handbooks. Otherwise, the moment of interia can be calculated as follows:

$$I_{solidcylinder} = \frac{\pi}{64}(OD)^4$$ where OD is the outside diameter of the stylet, or

$$I_{hollowtube} = \frac{\pi}{64}\left((OD)^4 - (ID)^4\right)$$ where OD is the outside diameter of the cannula and ID is the inside diameter.

[0037] In various embodiments, the bending stiffness of distal portion **20** of catheter **100** may be about 0.002 pound-inch squared (5.8×10^{-7} kg-meter squared) or less, such as about 0.001 pound-inch squared (2.9×10^{-7} kg-meter squared) or less, to prevent significant

damage to delicate tissue, such as the tissue surrounding the spinal canal or the cisterna magna, as distal portion **20** is being advanced through the tissue. In numerous embodiments, the bending stiffness of distal portion **20** of catheter **100** is between about 0.002 pound-inch squared (5.8×10^{-7} kg-meter squared) and 0.00005 pound-inch squared (1.4×10^{-8} kg-meter squared). Of course a catheter having such a low bending stiffness may be difficult to advance through the spinal canal. Accordingly, it may be desirable to use a stylet **200** (see, *e.g.*, **FIG. 3**) to assist in directing catheter **100** to the appropriate location within the subject. Distal portion **20** of catheter **100** and stylet **200** disposed within lumen **50** of distal portion **20** of catheter **100**, in combination, should be sufficiently stiff to advance distal portion **20** of catheter **100** through tissue. If distal portion **20** of catheter **100** is to be advanced through the spinal canal, distal portion **20** of catheter **100** and stylet **200** disposed within lumen **50** of distal portion **20** of catheter **100**, in combination, should have a bending stiffness of about 0.01 pounds inch squared (2.9×10^{-6} kg meter squared) or greater.

[0038] It will be desirable for distal portion **20** of catheter **100** to have sufficient hoop strength to resist collapse of the lumen **50** when the catheter **100** is implanted in the cerebrospinal fluid compartment of the subject. Examples of material that can impart sufficient hoop strength at the diameters discussed above include polypropylene and polyethylene.

[0039] Distal portion **20** of catheter **100** may vary in length to achieve a desired effect; e.g., advancement into the cisterna magna from a lumbar insertion. For example, the distal portion **20** may be about 40 cm or longer, about 50 cm or longer, about 60 cm or longer, about 70 cm or longer, about 80 cm or longer, about 90 cm or longer, or about 100 cm or longer. The longer the distal portion **20** of catheter **100**, which may have a small outer diameter, the less likely that catheter **100** will damage tissue as catheter **100** is advanced within a subject, and thus the more likely that it may be advanced extended distances in delicate tissue. In addition, due to a small outer diameter, distal portion **20** of catheter **100** may have a small inner diameter, which will permit fine control of fluid to be delivered. However, it should be noted that due to resistance to fluid flow associated with smaller inner diameter, catheter **100** preferably has a sufficiently large inner diameter to permit bolus delivery of fluid through the catheter **100**. While it will be understood that resistance may vary from solution to solution or catheter to catheter,

it may be difficult to deliver substantial bolus amounts if the inner diameter of the catheter (i.e., the lumen diameter) is less than about 0.127 mm.

[0040] In various embodiments, proximal end **10** of catheter **100** is configured to be coupled to an infusion device **300** (see, *e.g.*, **FIG. 10**). Proximal end **10** of catheter **100** may be coupled to infusion device **300** using any known or future developed mechanism. In embodiments wherein the outer diameter of distal portion **20** of catheter **100** is small, catheter **100** may include a tapered portion **500** between proximal end **10** and distal end **30** to provide a proximal end **10** with a larger outer diameter (see, *e.g.*, **FIG. 2A**) to facilitate coupling of the catheter **100** to the infusion device **300**. As shown in **FIG. 2B**, an adaptor **600** may be used to fluidly couple the lumen of the catheter **100** to a second catheter **700**, which may then be coupled to the infusion device. Of course, the adaptor **600** may be configured to couple catheter **100** directly to the infusion device.

[0041] Referring to **FIG. 3** and in accordance with various embodiments, the lumen **50** of the catheter is configured to slidably receive a stylet **200**. In the depicted embodiment, distal portion **20** of catheter **100** has a side hole delivery region **40**. Disposed within lumen **50** is a stylet **200** including a distal end **210**. As used herein, "stylet" means an elongated device capable of being inserted into lumen **50** of catheter **100** and assisting the movement of distal portion **20** of catheter **100** to a desired location in a subject, and includes a guidewire and the like. Stylet **200** may be used to push distal portion **20** of catheter **100** or may be used to impart stiffness to distal portion **20** of catheter **100** to allow catheter **100** to be positioned within a subject, *e.g.*, where the stylet **200** and the catheter **100** are advanced together. It will generally be desirable for excess catheter material to extend beyond distal end **210** of stylet **200** to allow material softer than stylet **200** to be exposed to tissue as distal portion **20** of catheter **100** and stylet **200** are advanced. Any way to ensure that distal end **210** of stylet **200** does not extend beyond distal end **30** of catheter **100** may be used. As shown in **FIG. 3**, a catheter **100** having a closed distal end **30** may be one way of preventing sytlet **200** from extending beyond distal end **30** of catheter **100**. Alternatively, catheter may be squeezed, *e.g.* by a user's fingers, to apply sufficient pressure to prevent relative longitudinal movement of stylet **200** to distal portion **20** of catheter **100** as distal portion **20** of catheter **100** and stylet **200** are advanced together.

[0042] **FIG. 4** depicts an embodiment of a catheter **100** having a feature **70** to prevent accidental extension of stylet **200** beyond distal end **30** of catheter **100** or accidental protrusion of stylet **200** through side hole delivery region **40**. As shown in **FIG. 4**, excess catheter material **80** may be present between the feature **70** and distal end **30** of catheter **100** to allow a material softer than stylet **200** to be exposed to tissue as catheter **100** and stylet **200** are being advanced. In the depicted embodiment, feature **70** is configured to receive distal end **210** of stylet **200**, which may be useful in circumstances where it is desirable to use stylet **200** to push distal portion **20** of catheter **100**.

[0043] Referring to **FIG. 5**, an alternative embodiment for preventing accidental extension of stylet **200** beyond distal end **30** of catheter **100** is shown. As shown in **FIG. 5**, stylet **200** may include a stop **230** or handle at the proximal region of stylet **200** that prevents distal end **210** of stylet **200** from extending beyond distal end **30** of catheter **100** during use. In various embodiments, the length of stylet **200** from stop **230** to distal end **210** of stylet **200** is less that the length of catheter **100** (if straightened) from proximal end **10** to distal end **30**. In various embodiments, the length of stylet **200** from stop **230** to distal end **210** of stylet **200** is less than the length of catheter **100** (if straightened) from proximal end **10** to an opening of delivery region **40**. It may be desirable for the length of stylet **200** to be shorter than the length of catheter **100** by an amount to allow sufficient excess catheter material to extend beyond distal end **210** of stylet **200** while catheter **200** is being advanced within a subject. The position of stop **230** on stylet **20** may be fixed or adjustable to the desired length.

[0044] Generally, stop **230** is configured to grippingly engage an outer surface of stylet **20** and to engage the proximal end of the catheter. If stop **230** is moveable along stylet **20**, the stop **230** may exist in an open state and a closed or engaged state. In the open state the stop **230** is moveable. In the closed state the stop **230** is fixed relative to the stylet **20**. In various embodiments, the stop **230** is actuatable between the open and closed states. Suitable actuatable mechanisms for stops **230** are well known and include set screws, squeezable handles or the like.

[0045] In various embodiments, kits including a catheter **100** as described herein and a stylet **200** are provided. Any suitable stylet **200**, such as a stylet as described above, may be

included in the kit. In numerous embodiments, the catheter **100** and the stylet **200** of the kit are provided in a single package.

[0046] Referring to **FIG. 6**, a cross-sectional representation of an embodiment of distal portion **20** of catheter **100** is shown. As shown in **FIG. 6**, a visualization marker **60** may be disposed in or about a portion of catheter **100** in proximity to delivery region **40** to serve as a proxy for identification of the location of the delivery region. Visualization marker **60** may be in the form of a band as shown in **FIG. 6**, or may take any other suitable form to serve as a means for localizing the placement of delivery region **40** by surgical navigation visualization techniques.

[0047] As shown in **FIG. 7**, stylet **200** may comprise visualization marker **220** at or near distal end **210** to further enhance visualization of navigation and placement of delivery region **40** of catheter **100**. Visualization marker **220** may be in the form of a band as shown in **FIG. 7**, or may take any other suitable form to serve as a means for localizing distal end **210** of stylet **200**, which may serve as a proxy for placement of delivery region **40** by surgical navigation visualization techniques. Visualization marker **220** may also be used to verify that distal end **210** of stylet **200** is not extended beyond distal end **30** of catheter **100** (as indicated by visualization marker **60** of catheter **100**) during placement of catheter **100**.

[0048] In various embodiments, at least a portion of distal portion **20** of catheter **100** comprises a coiled structure **90** when relaxed, as shown in **FIG. 8**. A "coiled structure", as used herein, may have one or more loops or other nonlinear portions (*e.g.*, a sigma structure) that may serve to anchor distal portion **20** of catheter **100** within a location of the body, such as the cisterna magna. Such a coiled structure **90** may be desirable in situations where catheter **100** is likely to undergo a strain due to body movements of the subject. For example, if catheter **100** is introduced into the intrathecal space of the spinal canal through a lumbar puncture and advanced rostrally so that distal portion **20** of catheter **100** is located in the cisterna magna, movement of the subject's head or neck may tend to dislodge distal portion **20** of catheter **100** from the cisterna magna. As such, a coiled structure portion **90** of distal portion **20** of catheter **100** may serve to provide strain relief to prevent pulling or dislodging of distal portion **20** of catheter **100**. Such a coiled structure portion **90** may also be beneficial

when catheter **100** is implanted in an infant or child, where growth of the spine may otherwise tend to dislodge distal portion **20** of catheter **100** from its desired location, *e.g.* the cisterna magna. The coiled structure portion **90** of distal portion **20** of catheter **100** is sufficiently pliable to be straightened when a stylet **200** is inserted into lumen **50** of catheter **100** and extended through coiled portion **90** of catheter **100**. In addition to providing strain relief, coiled structure portion **90** may also serve to anchor distal portion **20** of catheter **100** in place.

[0049] It may be desirable to include one or more visualization markers **60** (not shown in **FIG. 8**) on coiled structure portion **90** to verify that the coiled structure portion **90** has been appropriately implanted or navigated. Alternatively, it may be desirable to incorporate radiopaque material into catheter material of coiled structure portion **90** to allow for visualization during or after implant.

[0050] Referring to **FIG. 9**, a representation of an embodiment of distal portion **20** of catheter **100** as it may appear implanted in a subject is shown. Distal portion **20**, which may be implanted in the cisterna magna, comprises a coiled structure portion **90** comprising distal end **30** of catheter **100**. Included in the depicted coiled structure portion **90** are delivery regions **40** and visualization marker **60**. Placement of delivery region **40** within the coiled structure region **90** may serve to keep delivery region located away from a tissue of the subject, rather than allowing the delivery region to contact or be in close proximity to tissue of the subject when implanted. Such a configuration may be desirable to prevent granulomas that may occur with certain intrathecally delivered drugs.

[0051] While not shown, it will be understood that it may be desirable for coiled structure region **90** to comprise more than one visualization marker **60** or to have a visualization marker **60** extend over a substantial portion of coiled structure region **90**, e.g., by incorporating a radiopaque material into the catheter at coiled structure region **90**.

[0052] Distal portion **20** of catheter **100** may comprise one or more tines **110** to assist in anchoring distal portion **20**, and more particularly delivery region **40**. Tines **110** may be located at any location along catheter **100** that may result in anchoring the catheter **100** or reduce movement of delivery region **40**. As shown in **FIG. 9**, tines **110** may be located further from distal end **30** of catheter **100** than coiled structure portion **90** (*e.g.*,

the tines are located proximal to the coiled structure region), *e.g.* at a location of catheter **100** to be implanted within a spinal canal. Also shown in **FIG. 9**, is that excess **120** catheter **100** may be placed in the spinal canal to provide slack to allow for growth of a subject, such as a child. Tines **110** may be made of any material that can provide sufficient anchoring to inhibit movement of the catheter relative to the tissue in which the tines **110** are anchoring the catheter. In the depicted embodiment, the tines **110** are oriented to allow rostral advancement of the catheter in the spinal canal but to inhibit caudal withdrawal or movement of the distal portion **20** of the catheter. However, the tines **110** may be retractable, as is known in the art, to prevent damage to the spinal canal upon withdrawal of the catheter. One example of retractable tines is presented in US Patent No. 6,695,861.

[0053] Referring to **FIG. 10**, catheter **100** is shown operably coupled to an infusion device **300**. Catheter **100** may be connected to infusion device **300** via catheter connector **330**. Infusion device **300** shown in **FIG. 10** comprises a refill port **310** in fluid communication with a reservoir (not shown) for housing a fluid to be infused to into a subject via catheter **100**, which is in fluid communication with reservoir. Infusion device **300** as depicted in **FIG. 10** also comprises an injection port **320**, which is in fluid communication with catheter. Fluid, *e.g.* fluid containing therapeutic agent, may be injected into injection port **320**, *e.g.* to deliver a bolus of therapeutic agent. Examples of infusion devices **300** having injection ports **310** in fluid communication with reservoirs and having injection ports **320** are Medtronic, Inc.'s SynchroMed® series of infusion devices. While not shown, it will be understood that infusion device **300** may be any device that is capable of delivering a fluid through catheter **100**, such as a syringe, a device having a pump (*e.g.*, osmotic, peristaltic, piston, etc.), an access port, and the like.

[0054] Referring to **FIG. 11**, a programmable infusion device **300**, such as Medtronic, Inc.'s SynchroMed® series of infusion devices, is shown implanted in a human. As shown in **FIG. 11**, distal end **30** of catheter **100** may be inserted into a subject's spinal canal through a lumbar puncture and advanced rostrally through the spinal canal to a desired location. Proximal end **10** of catheter **100** is coupled to infusion device **300**, which is typically implanted in the subject at a subcutaneous location. Infusion device **300** comprises a receiver **42** (or transmitter) which is capable of telemetric communication

(or any other suitable form of communication) with programmer **400**. Programmer **400** may communicate with an implantable infusion device **300** to adjust the amount of therapeutic agent delivered. Communication may be unidirectional; e.g., programmer **400** to infusion device **300**, or bi-directional. Generally, programmer **400** is placed over skin in an area where infusion device **300** is implanted to communicate with device **300**. While not shown, it will be understood that one or more sensors may be operably coupled to infusion device **300** to alter the rate at which therapeutic agent is delivered. Programmable infusion devices are particularly amenable to alteration of infusion rate via sensors. One advantage of the use of programmable infusion devices over non-programmable devices is that the rate of delivery of therapeutic agent from infusion device **300** may be altered as a patient's condition warrants or to optimize therapeutic efficacy.

[0055] In general, it will be understood that catheter **100**, or portions thereof, may be made of any material that is compatible with a subject in which catheter **100** is implanted and with fluid to be delivered through catheter **100**. Material selection for the catheter may be based on mechanical properties of the tubing, drug stability (changes in the drug due to the catheter material), drug compatibility (changes in the catheter material due to the drug), biostability (changes in the material due to the in vivo environment), biocompatibility (effects of the material on the patient), and the like. Generally catheter **100** or portions thereof will be made of polymeric material such as silicone, polyurethane, polyethylene, polypropylene, or the like. If polypeptides are to be delivered via catheter **100**, it may be desirable to use polymeric materials other than silicone, as the polypeptide may adhere to or be absorbed into the silicone or may be degraded.

[0056] Thus, embodiments of the INTRATHECAL CATHETER are disclosed. One skilled in the art will appreciate that the present invention can be practiced with embodiments other than those disclosed. The disclosed embodiments are presented for purposes of illustration and not limitation, and the present invention is limited only by the claims that follow.

What is claimed is:

1. An intrathecal catheter for delivering fluid to, or withdrawing fluid from, the cerebrospinal fluid compartment of a subject, the catheter comprising:

a proximal end;

a distal portion having

an outer diameter of about 1 mm or less,

a bending stiffness of between about 0.0005 pounds-inch squared to about 0.002 pounds-inch squared, and

a distal end;

a delivery region located between the proximal end and the distal end; and

a lumen extending from the proximal end to the delivery region,

wherein the material forming the distal portion of the catheter has sufficient hoop strength to resist collapsing of the lumen when implanted in the cerebrospinal fluid compartment.

2. A catheter according to claim 1, further comprising a visualization marker disposed in or about the distal portion in proximity to the delivery region.

3. A catheter according to claim 1 or claim 2, wherein the length of the catheter from the proximal end to the delivery region is about 40 cm or more.

4. A catheter according to any of claims 1-3, wherein the distal portion further comprises a coiled structure region.

5. A catheter according to claim 4, wherein the delivery region located in the coiled structure region.

6. A catheter according to claim 4 or claim 5, wherein the coiled structure region is capable of being straightened upon insertion of a stylet into the lumen of the catheter.

7. A catheter according to any of claims 1-6, wherein the catheter is formed from a polymeric material.

8. A catheter according to any of claims 1-6, wherein the catheter is formed from a material comprising polypropylene.

9. A catheter according to any of claims 1-6, wherein the catheter is formed from a material comprising polyethylene.

10. A kit comprising:

a catheter according to any of claims 1-9; and

a stylet having a proximal end, and a distal portion, the distal portion comprising a distal tip and being configured to be slidably disposable in the lumen of the catheter.

11. A kit according to claim 10, further comprising a stop mechanism configured to grippingly engage an outer surface of the stylet and to engage the proximal end of the catheter as the stylet is inserted into the lumen of the catheter to prevent the stylet from being advanced into the lumen beyond a point where the distal tip of the stylet extends through the lumen and beyond the delivery region of the catheter.

12. A kit according to claim 11, wherein the stop mechanism is capable of being actuated between an open and a closed state, wherein the stop mechanism in the

open state is moveable relative to stylet and wherein the stop mechanism in the closed state is configured to grippingly engage the stylet.

13. A kit according to claim 10, further comprising a stop mechanism configured to grippingly engage an outer surface of the stylet and to engage the proximal end of the catheter as the stylet is inserted into the lumen of the catheter, wherein the length of stylet from location of stop mechanism to distal tip is less than length of the lumen from proximal end of catheter to delivery region.

14. A system comprising:

a catheter according to any of claims 1-9; and

an implantable infusion device operably couplable to the catheter such that fluid is deliverable from the device to a patient via the delivery region of the catheter when the system is implanted in the patient.

15. A catheter comprising:

a proximal end;

a distal portion including a delivery region and a coiled structure region;

one or more tines located proximal to the delivery region and the coiled structure region; and

a lumen extending from the proximal end to the delivery region.

16. A catheter according to claim 15, wherein the delivery region is located within the coiled structure region.

17. A catheter according to claim 15, wherein the delivery region is located distal to the coiled structure region.

18. A catheter according to any of claims 15-17, wherein the coiled structure region is capable of being straightened upon insertion of a stylet into the lumen of the catheter.

19. A system comprising:

a catheter according to any of claims 15-18; and

an implantable infusion device operably couplable to the catheter such that fluid is deliverable from the device to a patient via the delivery region of the catheter when the system is implanted in the patient.

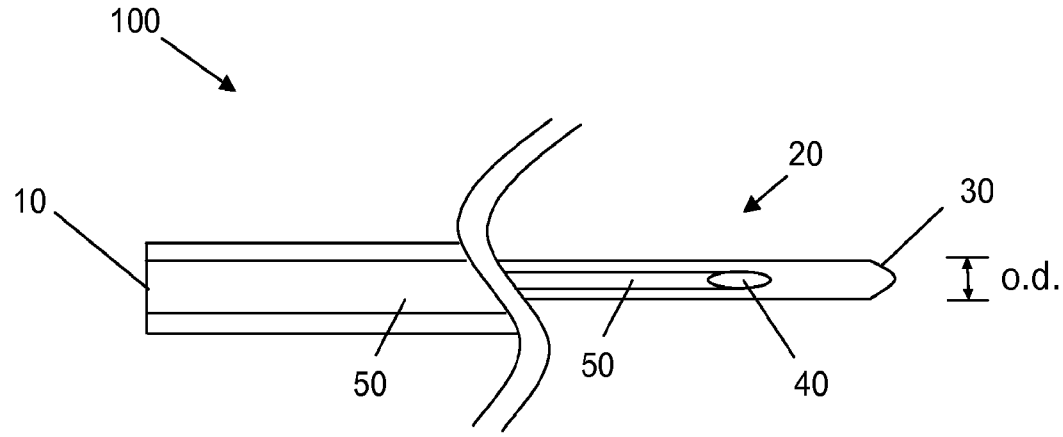


FIG. 1

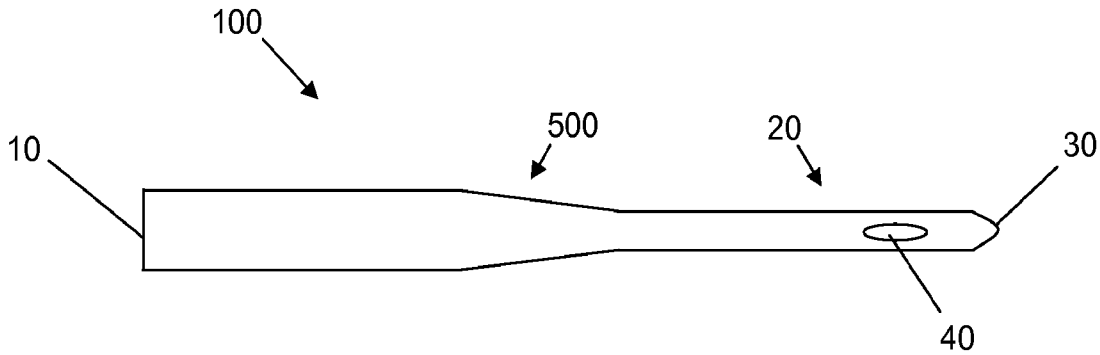


FIG. 2A

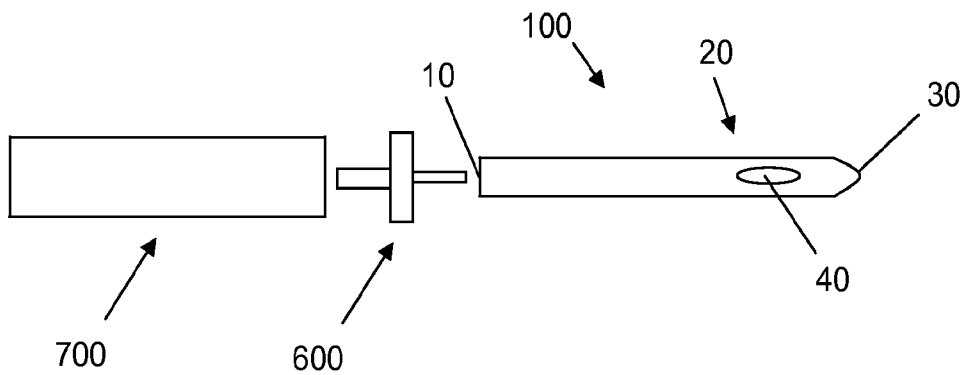


FIG. 2B

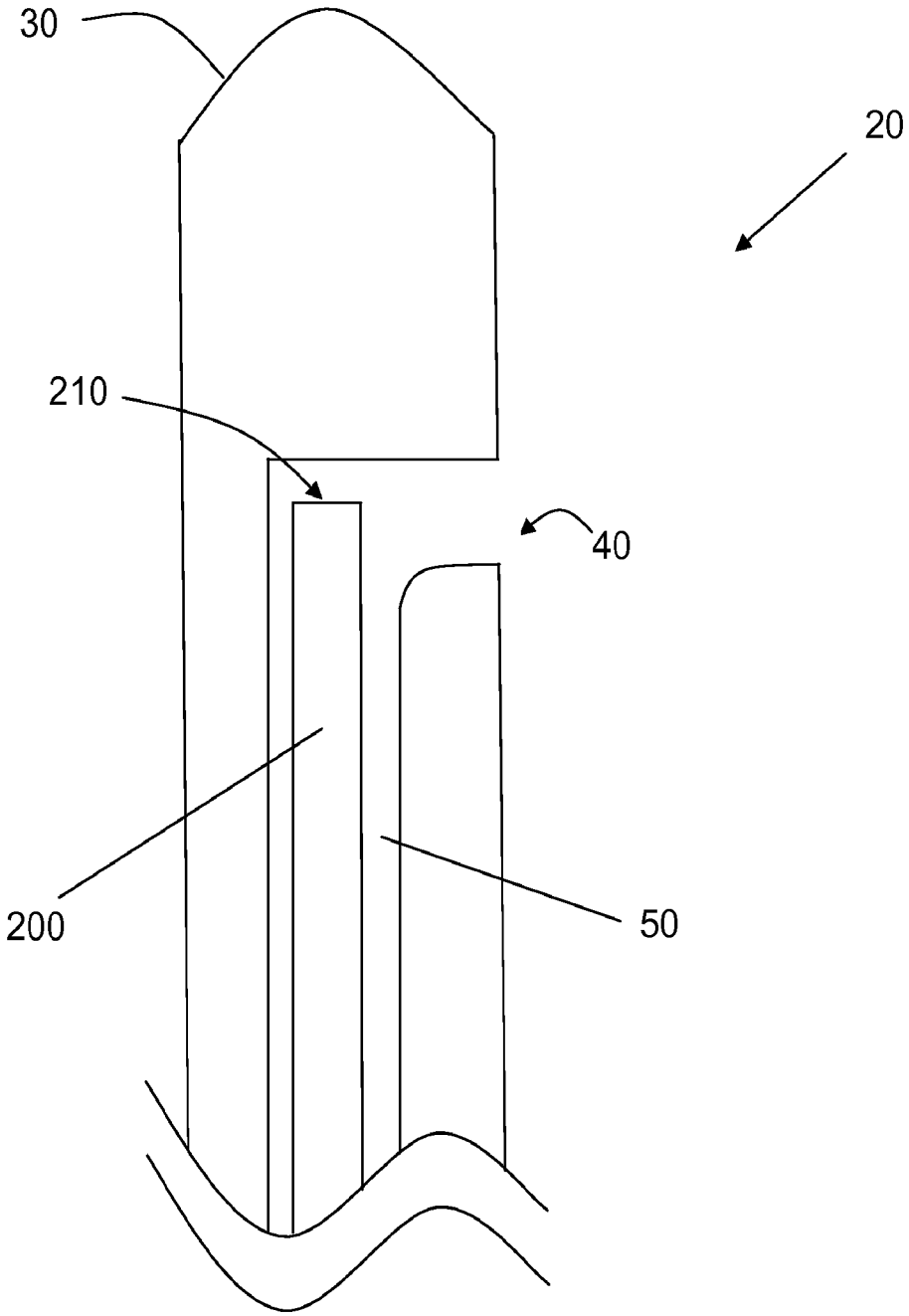


FIG. 3

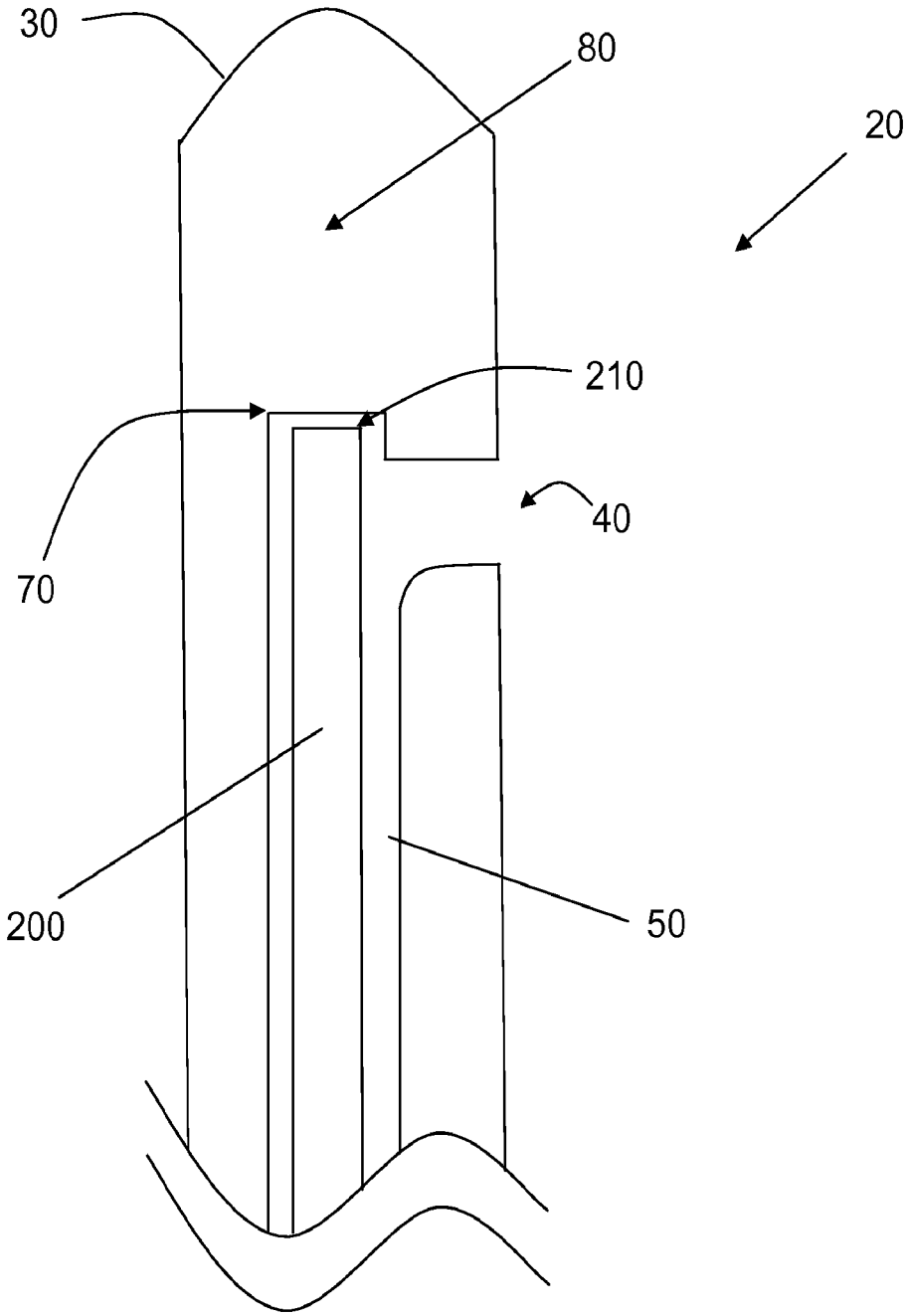


FIG. 4

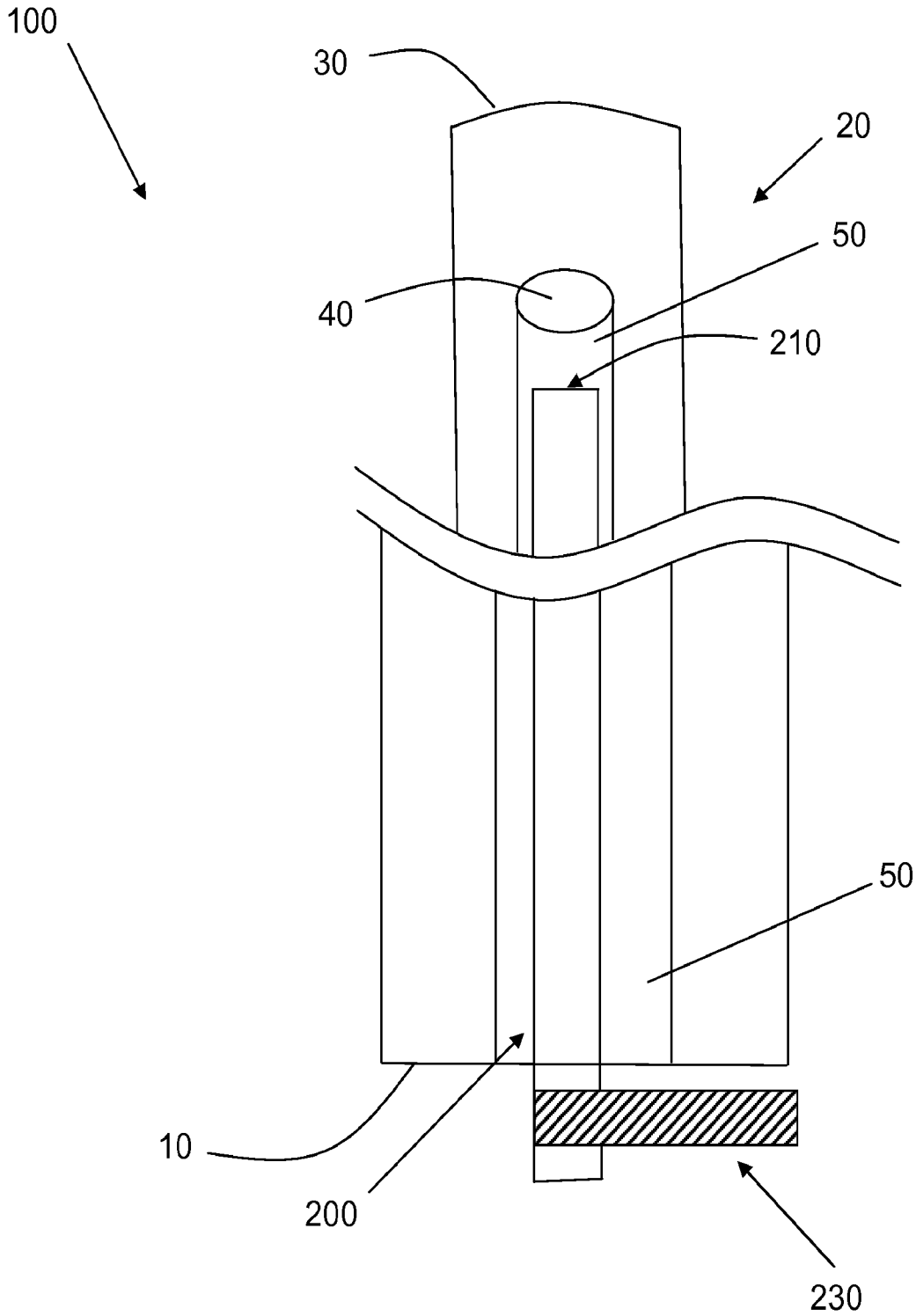


FIG. 5

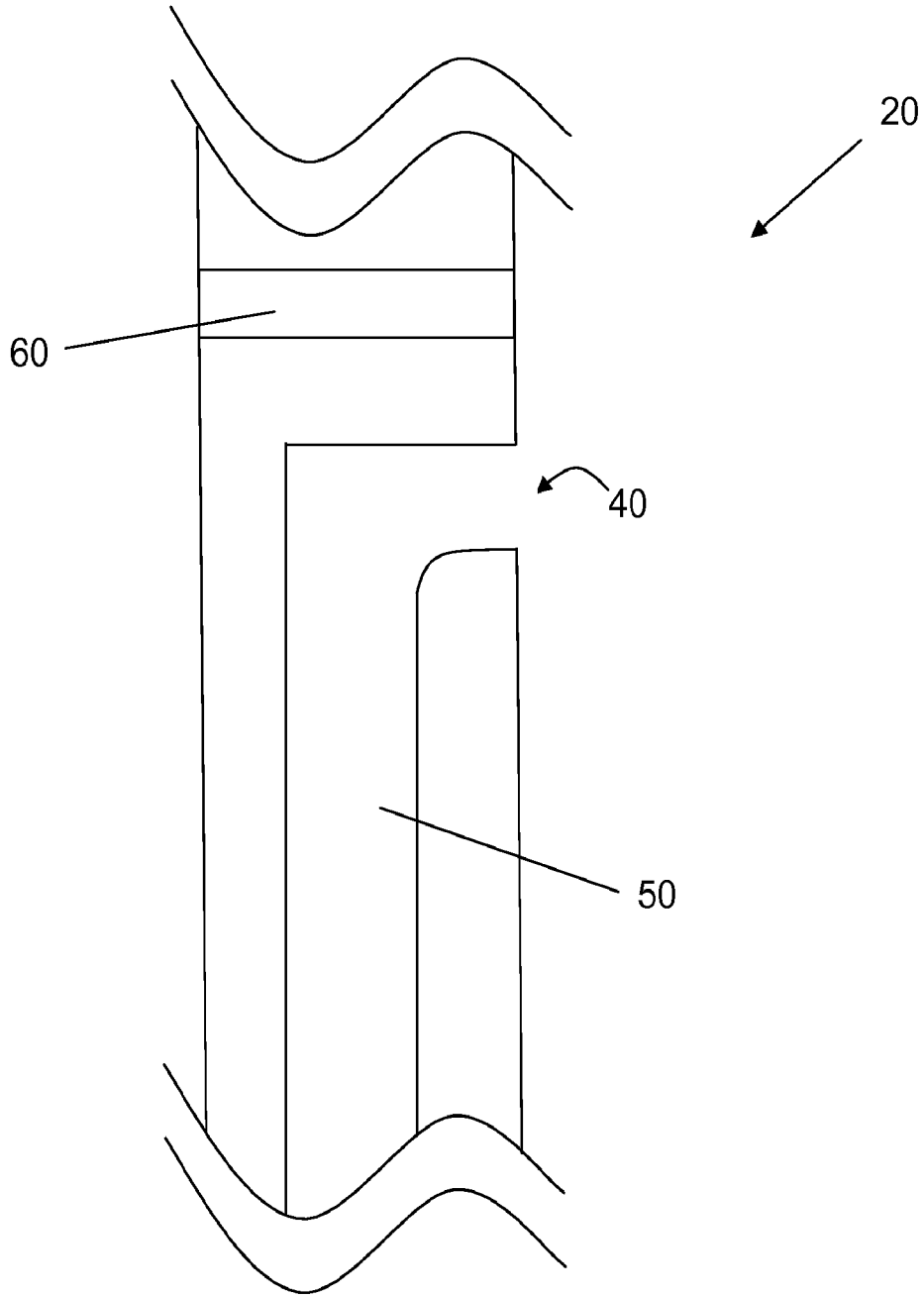


FIG. 6

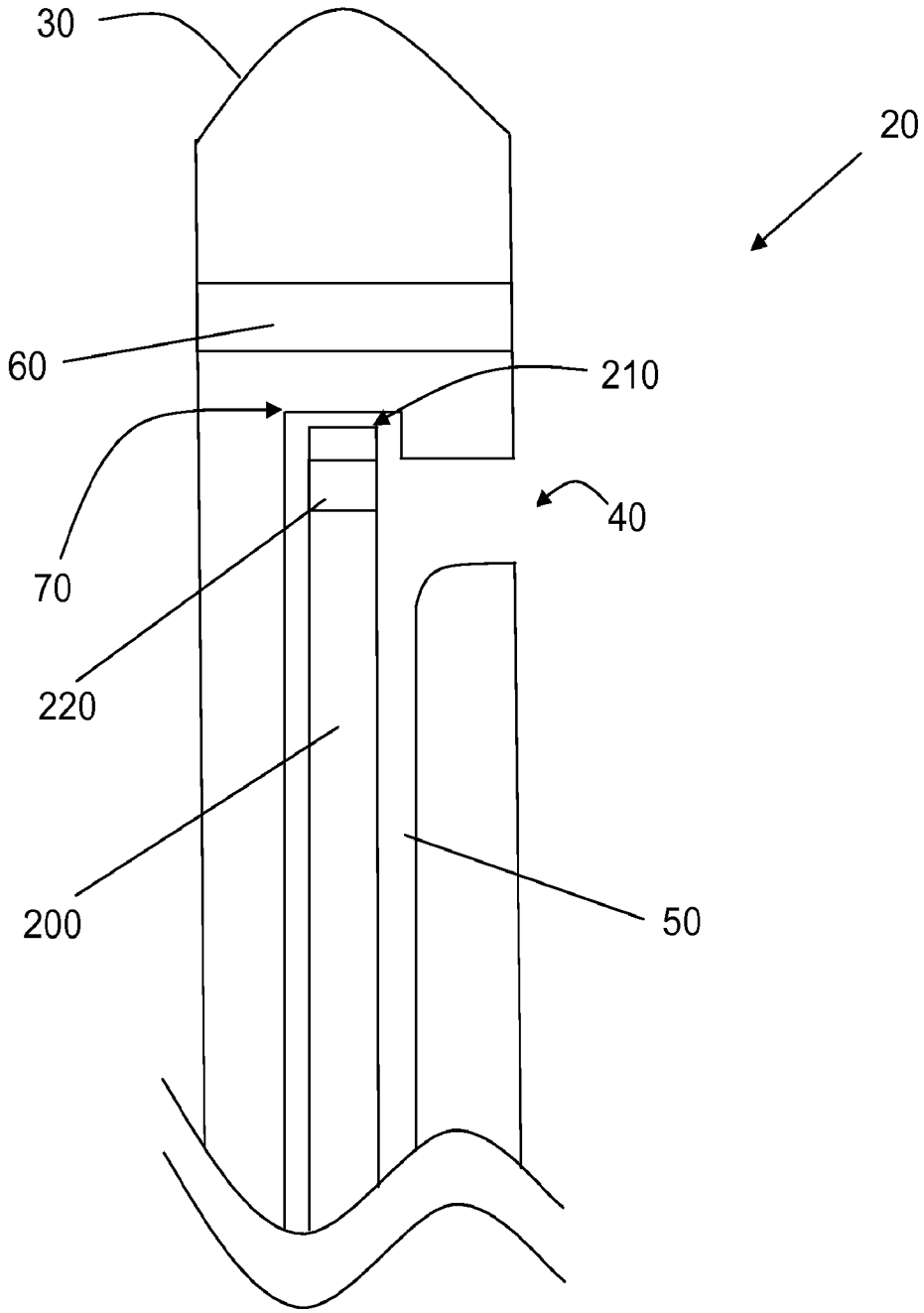


FIG. 7

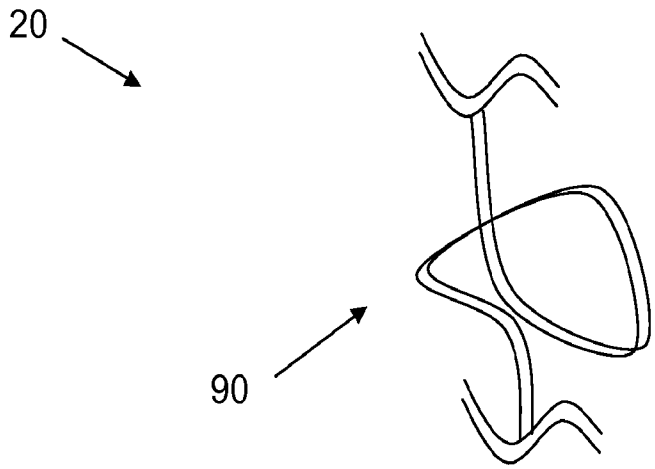


FIG. 8

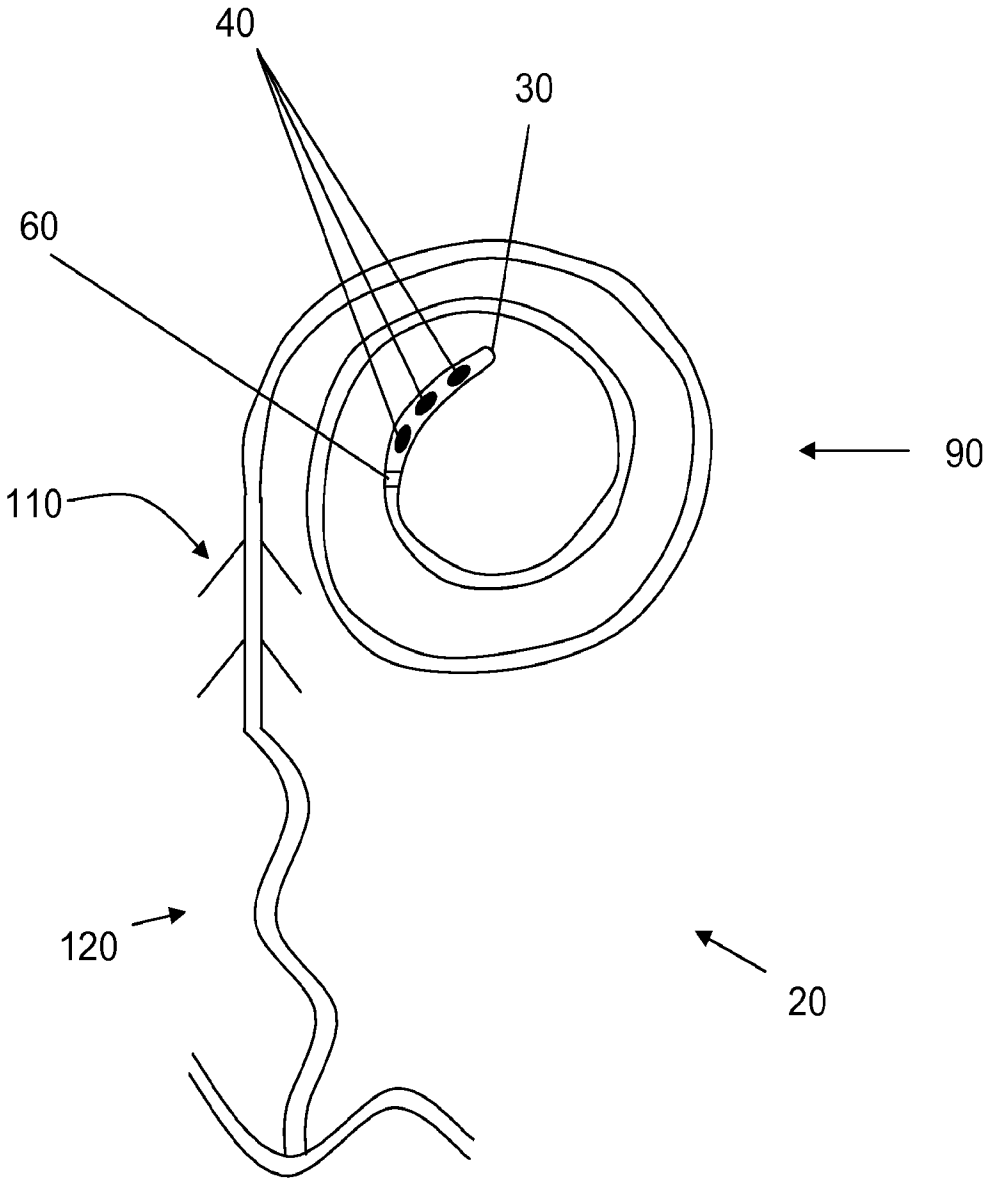


FIG. 9

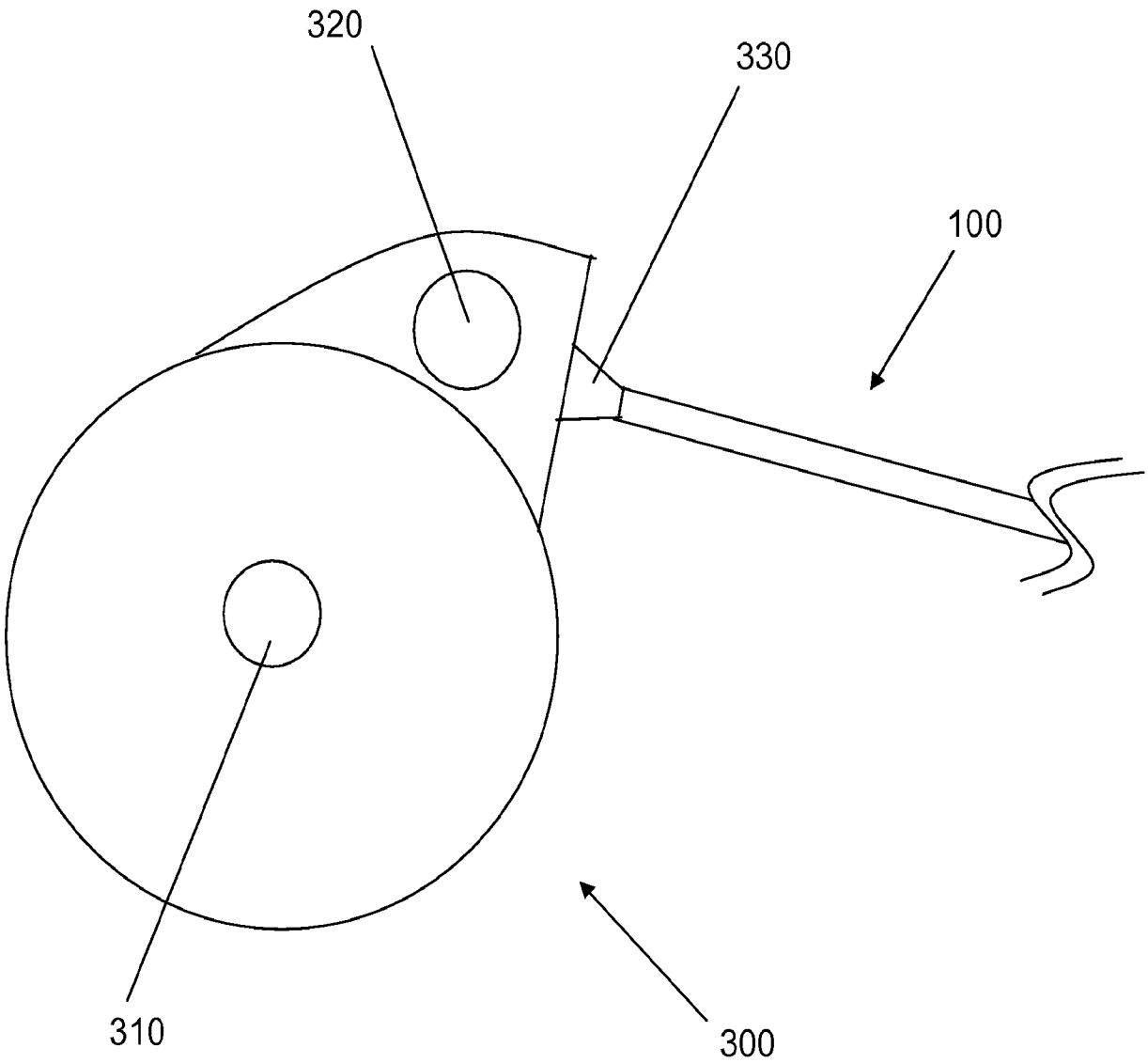


FIG. 10

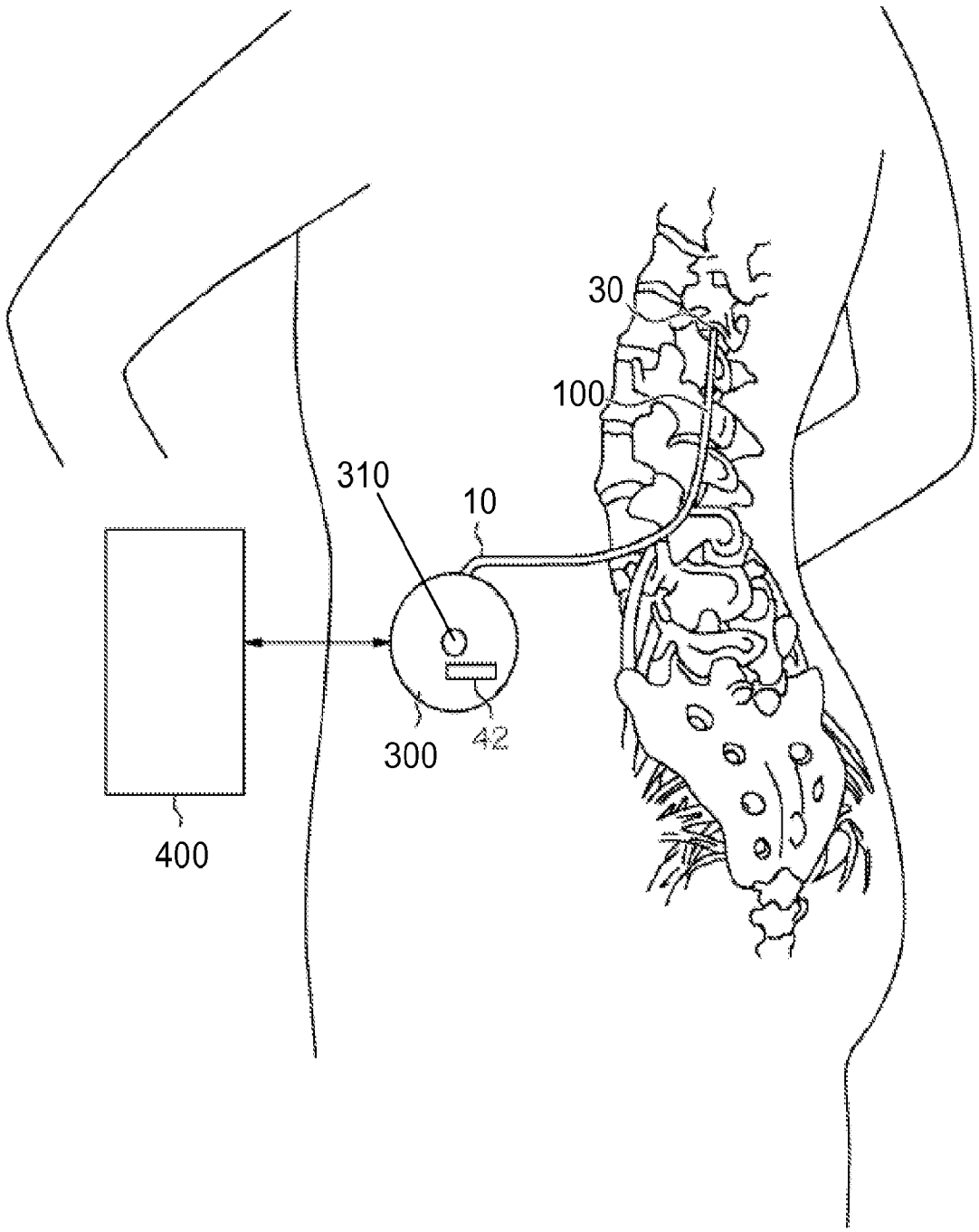


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/086629

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61M25/00 A61M27/00 A61M31/00 A61M25/04
ADD. A61M25/01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	US 2006/282043 A1 (PYLES STEPHEN T [US]) 14 December 2006 (2006-12-14) page 1, paragraph 2 - page 1, paragraph 3 page 1, paragraph 6 - page 1, paragraph 10 page 2, paragraph 17 - page 2, paragraph 23; figures 1-4 page 3, paragraph 26; claims 1-18	1-16,19
X	US 2004/082914 A1 (HOOPER SANDRA MARIE [US]) 29 April 2004 (2004-04-29) page 1, paragraph 1 page 1, paragraph 12 - page 2, paragraph 14 page 2, paragraph 32 - page 3, paragraph 47; figures 1-8	1-3, 7-10,13, 14

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 April 2008	07. 05. 2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Rolland, Philippe

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/086629

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 01/13984 A (NEURON THERAPEUTICS INC [US]; GUNASEKARA INDAKA [US]; GRIFFIN MARK [US]) 1 March 2001 (2001-03-01) page 1, line 3 - page 1, line 6 page 3, line 3 - page 3, line 12 page 3, line 29 - page 4, line 4 page 7, line 4 - page 9, line 2 page 12, line 3 - page 12, line 10; figure 5 page 20, line 8 - page 23, line 3; figures 9A-13	1-10, 15-19
X	US 5 676 659 A (MCGURK ERIN [US]) 14 October 1997 (1997-10-14) column 1, line 9 - column 1, line 67 column 2, line 23 - column 2, line 64 column 3, line 35 - column 3, line 46 column 4, line 30 - column 5, line 53; figures 1,2 column 6, line 29 - column 6, line 64	1-3,7-9, 14
A	US 5 984 896 A (BOYD ROBERT B [US]) 16 November 1999 (1999-11-16) column 1, line 3 - column 1, line 5 column 2, line 16 - column 3, line 10 column 4, line 61 - column 5, line 43; figure 1 column 7, line 10 - column 7, line 18; figures 11,12	15-19
A	US 2004/068251 A1 (CHAN TAI WAH [US] ET AL) 8 April 2004 (2004-04-08) page 1, paragraph 2 page 2, paragraph 17 - page 2, paragraph 20 page 4, paragraph 53 - page 4, paragraph 55 page 5, paragraph 61 - page 5, paragraph 62 page 6, paragraph 71 - page 6, paragraph 71 figures 1-6	1-14
A	US 2001/047164 A1 (TEAGUE JAMES [US] ET AL TEAGUE JAMES A [US] ET AL) 29 November 2001 (2001-11-29) page 1, paragraph 2 page 1, paragraph 4 page 1, paragraph 6 page 2, paragraph 13 page 3, paragraph 35 - page 3, paragraph 38 page 4, paragraph 45 - page 4, paragraph 50; figures 1-6 page 5, paragraph 53 - page 5, paragraph 56; figures 8-10	15,16, 18,19

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2007/086629

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2006282043 A1	14-12-2006	NONE	
US 2004082914 A1	29-04-2004	NONE	
WO 0113984 A	01-03-2001	AU 8034000 A	19-03-2001
		CA 2382871 A1	01-03-2001
		CN 1370086 A	18-09-2002
		EP 1207931 A2	29-05-2002
		JP 2003507140 T	25-02-2003
		MX PA02001866 A	25-09-2003
US 5676659 A	14-10-1997	CA 2176389 A1	18-05-1995
		DE 69432359 D1	30-04-2003
		DE 69432359 T2	24-12-2003
		EP 0744977 A1	04-12-1996
		ES 2194896 T3	01-12-2003
		JP 9507399 T	29-07-1997
		WO 9513110 A1	18-05-1995
US 5984896 A	16-11-1999	NONE	
US 2004068251 A1	08-04-2004	EP 1418975 A2	19-05-2004
		WO 03009883 A2	06-02-2003
		US 2003028174 A1	06-02-2003
US 2001047164 A1	29-11-2001	US 2003191450 A1	09-10-2003